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Long

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(54) **CONTROL SYSTEM FOR A PORTABLE INSTANT HOT WATER HEATER**

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See application file for complete search history.

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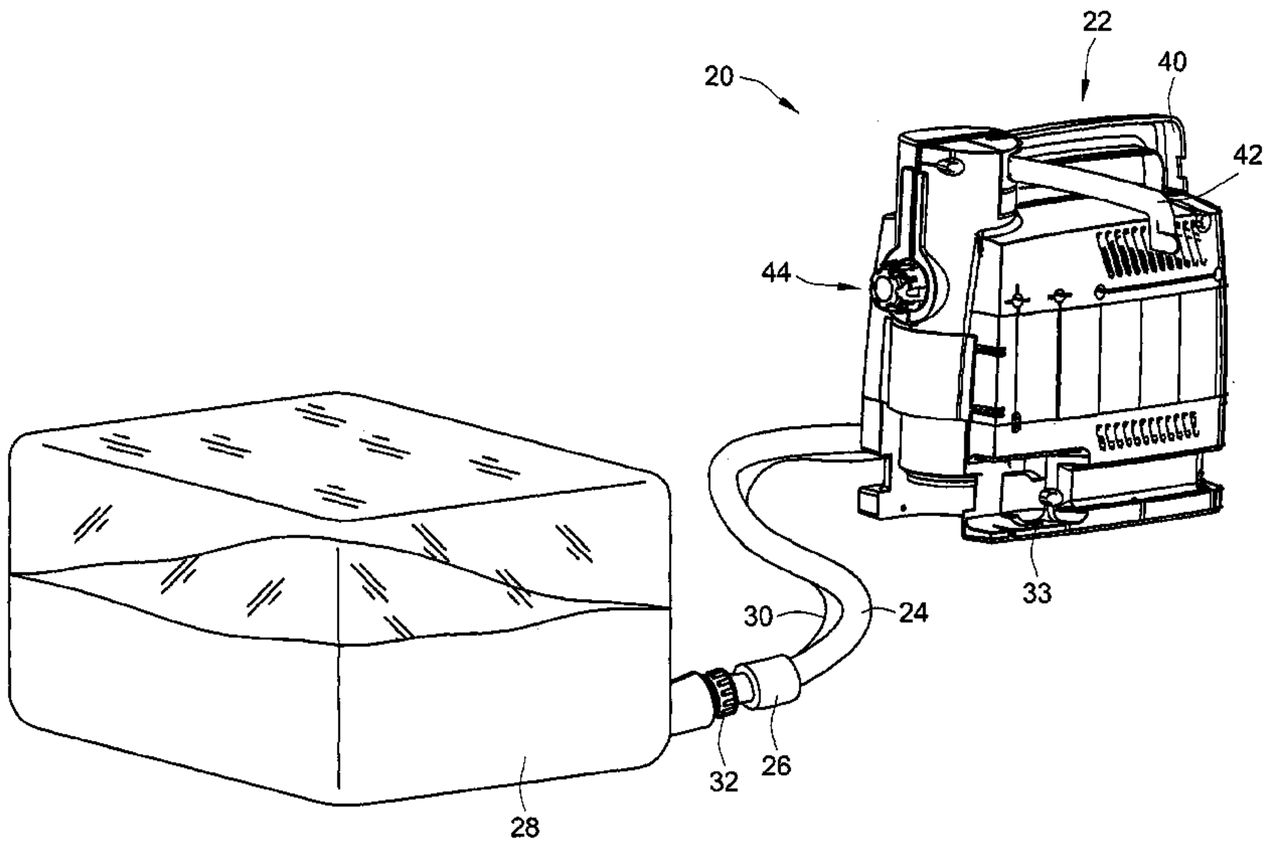
(57) **ABSTRACT**

A portable instant water heater. Water is delivered to a base unit of the instant hot water heater by a pump that draws water from a reservoir through a flow control valve. The water flows into a pre-heater that wraps around a base of the burner and that is heated by the burner. Water is heated in a heat exchanger and then exits the base unit through an outlet spout that swings out from the base unit to dispense water and that may be stored and locked into position in a handle for the base unit. The flow control valve may lower the flow of water through the heat exchanger, so the water has more time to absorb heat and to get hotter. The base unit includes a single control knob that turns on the pump and the burner and operates the flow control valve.

7 Claims, 12 Drawing Sheets



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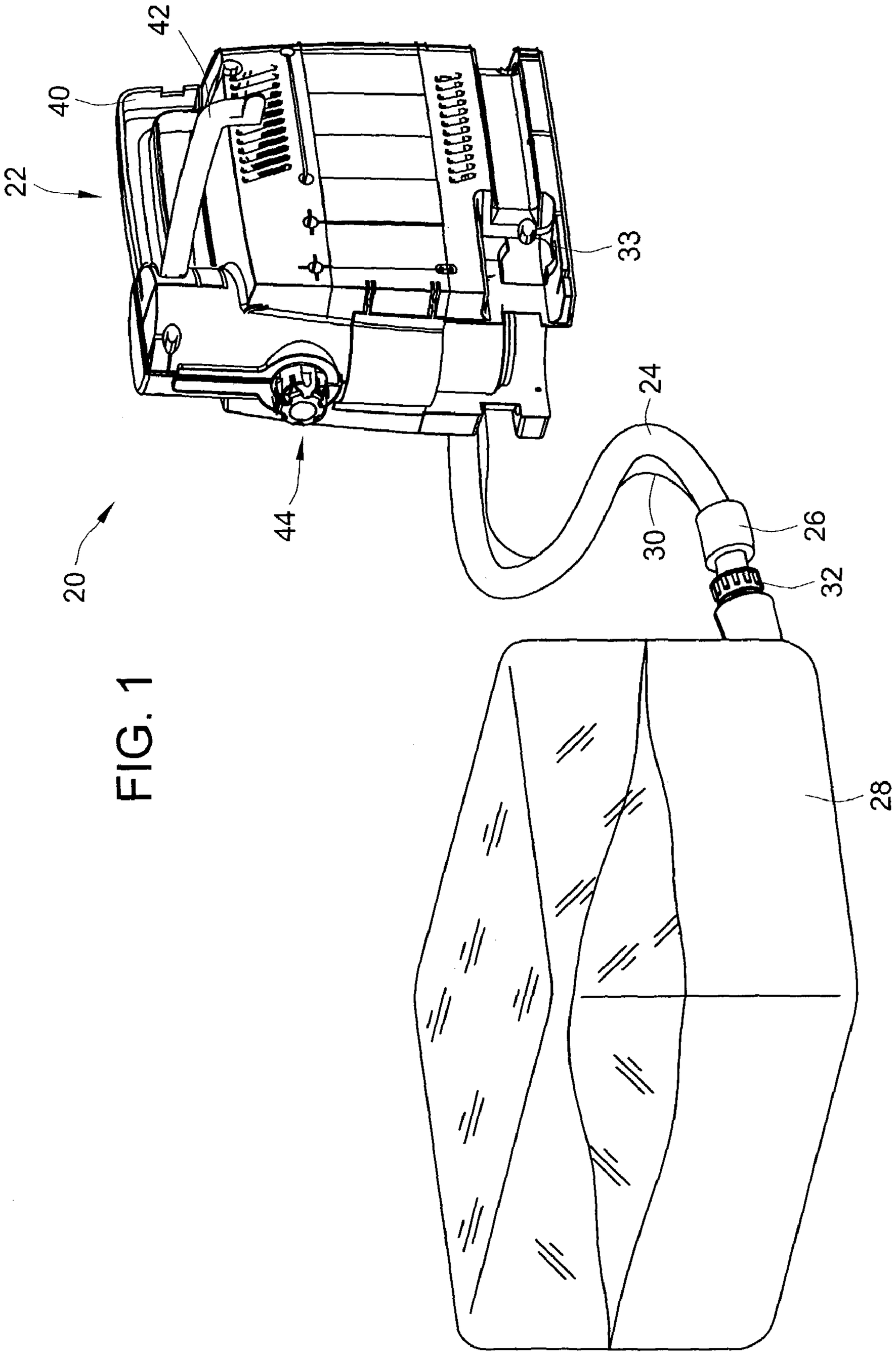


FIG. 1

FIG. 2

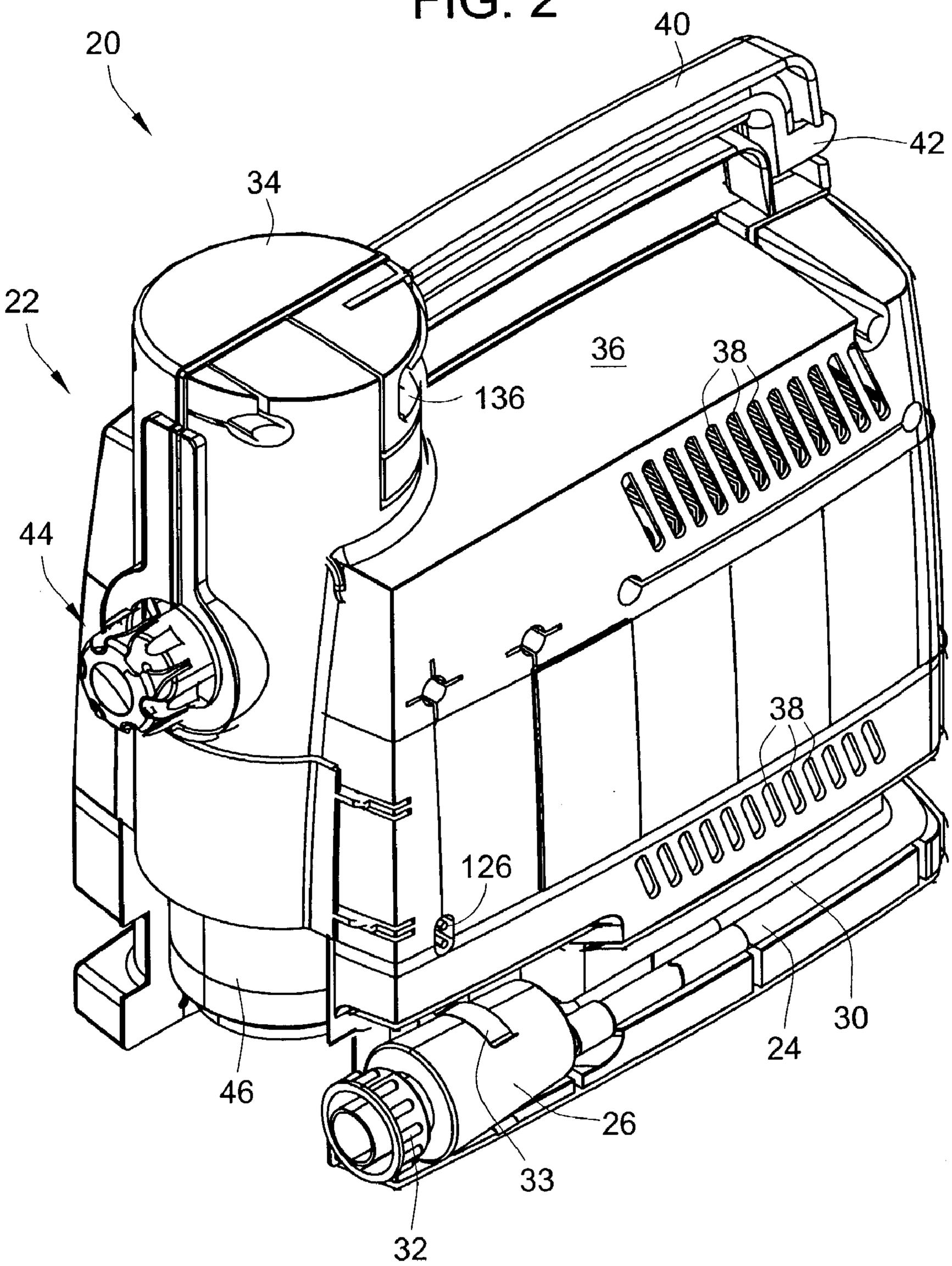


FIG. 3

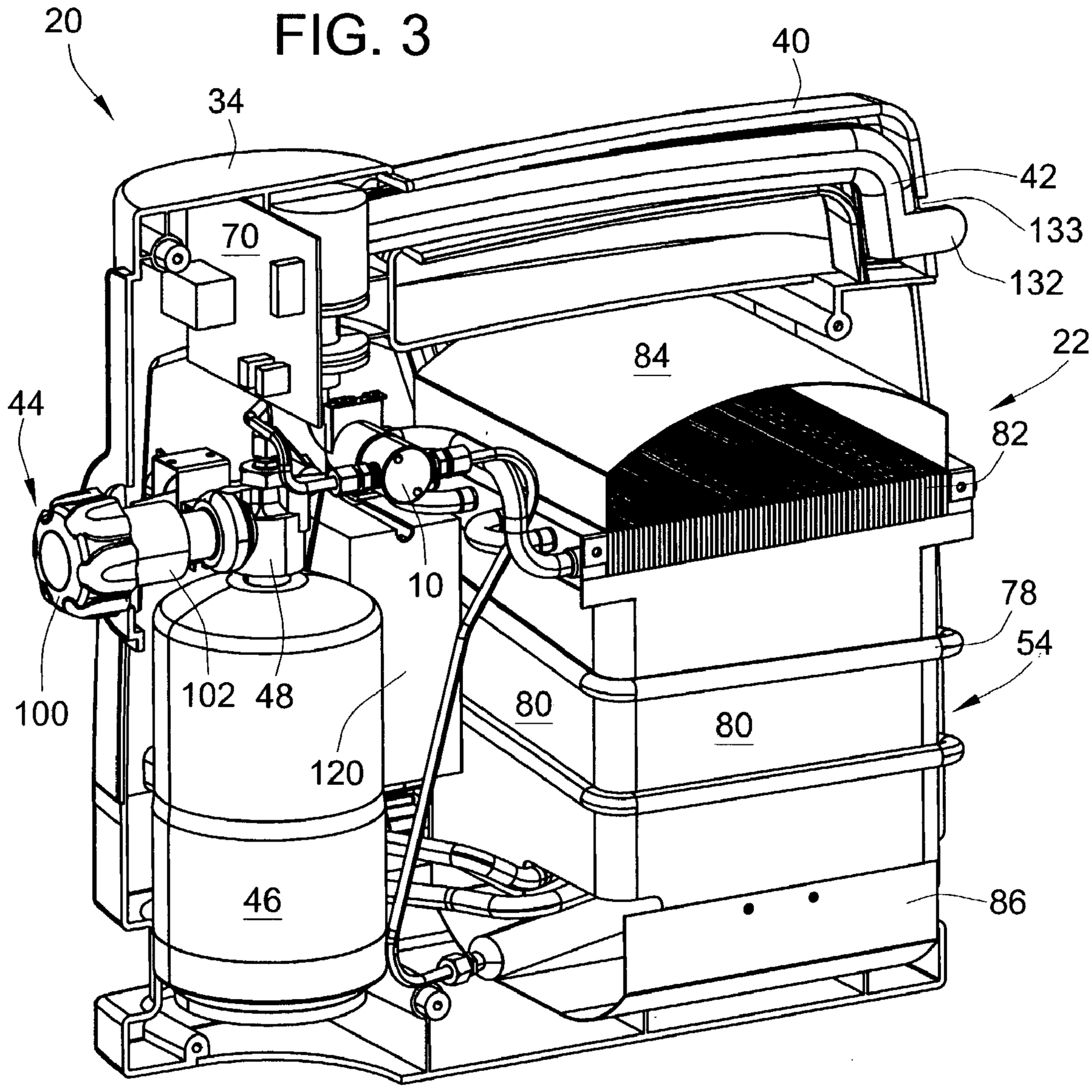
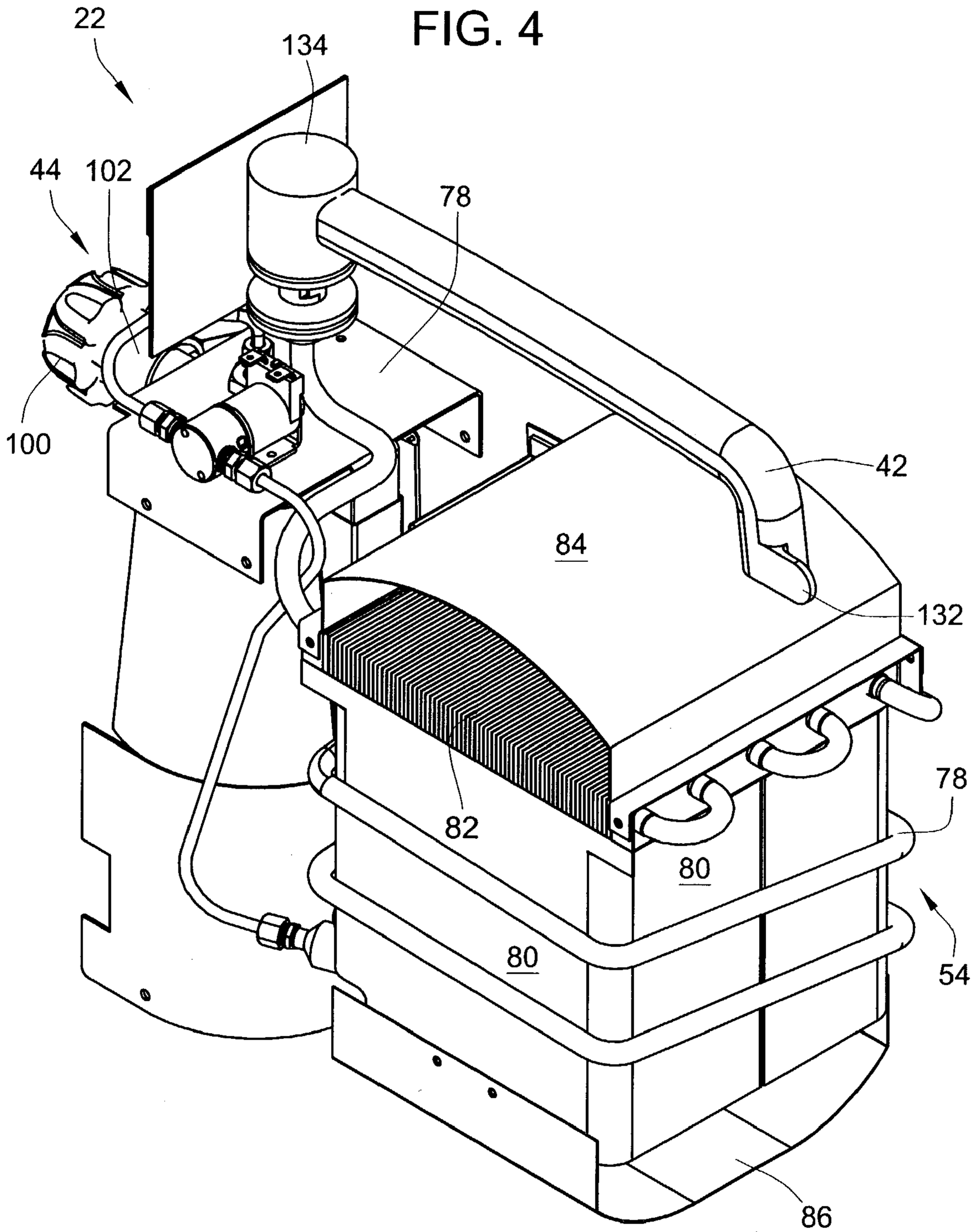


FIG. 4



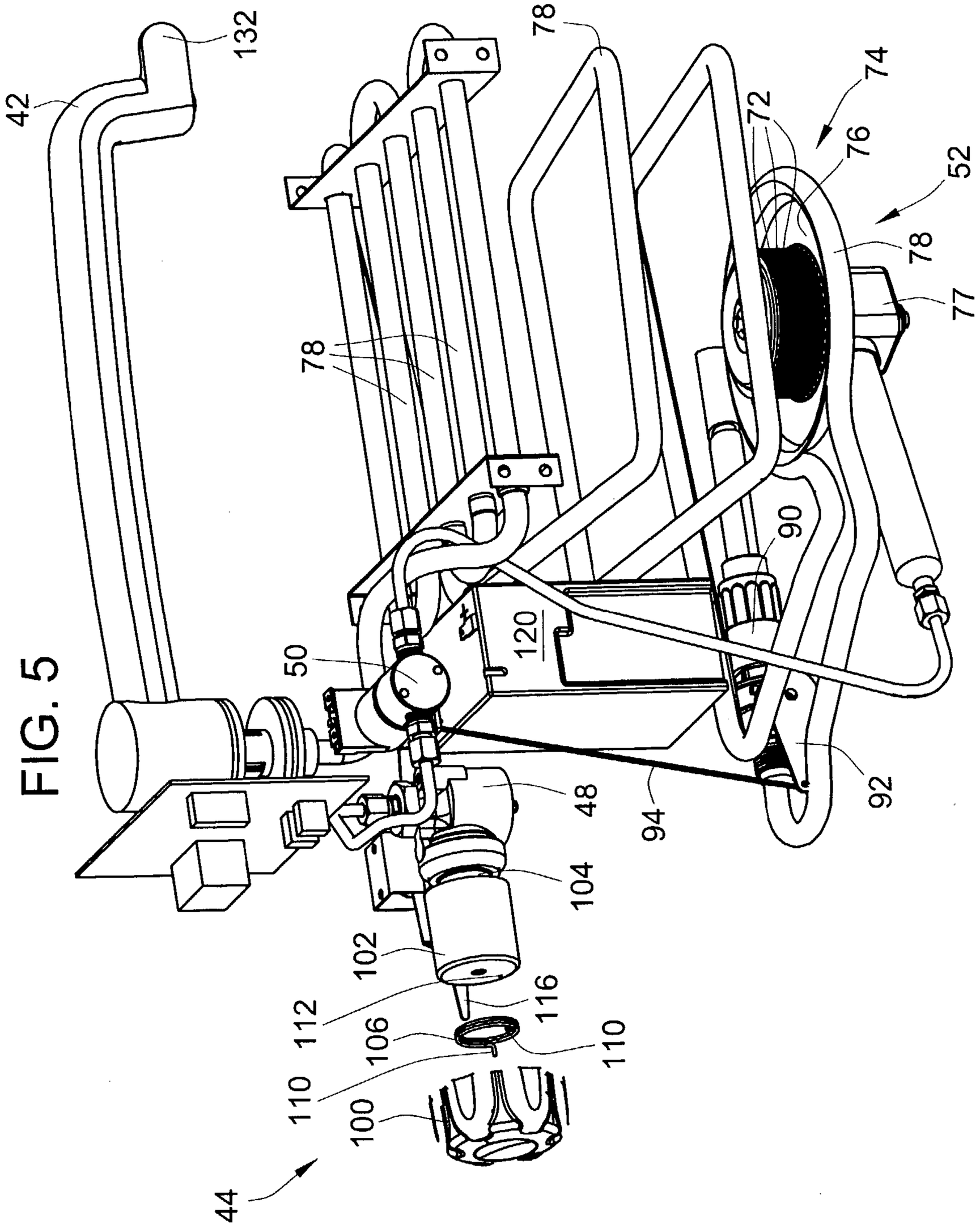

42
132
78
74
72
76
52
78
77
78
90
120
50
48
94
92
104
102
112
106
110
116
110
100
44

FIG. 5

FIG. 6

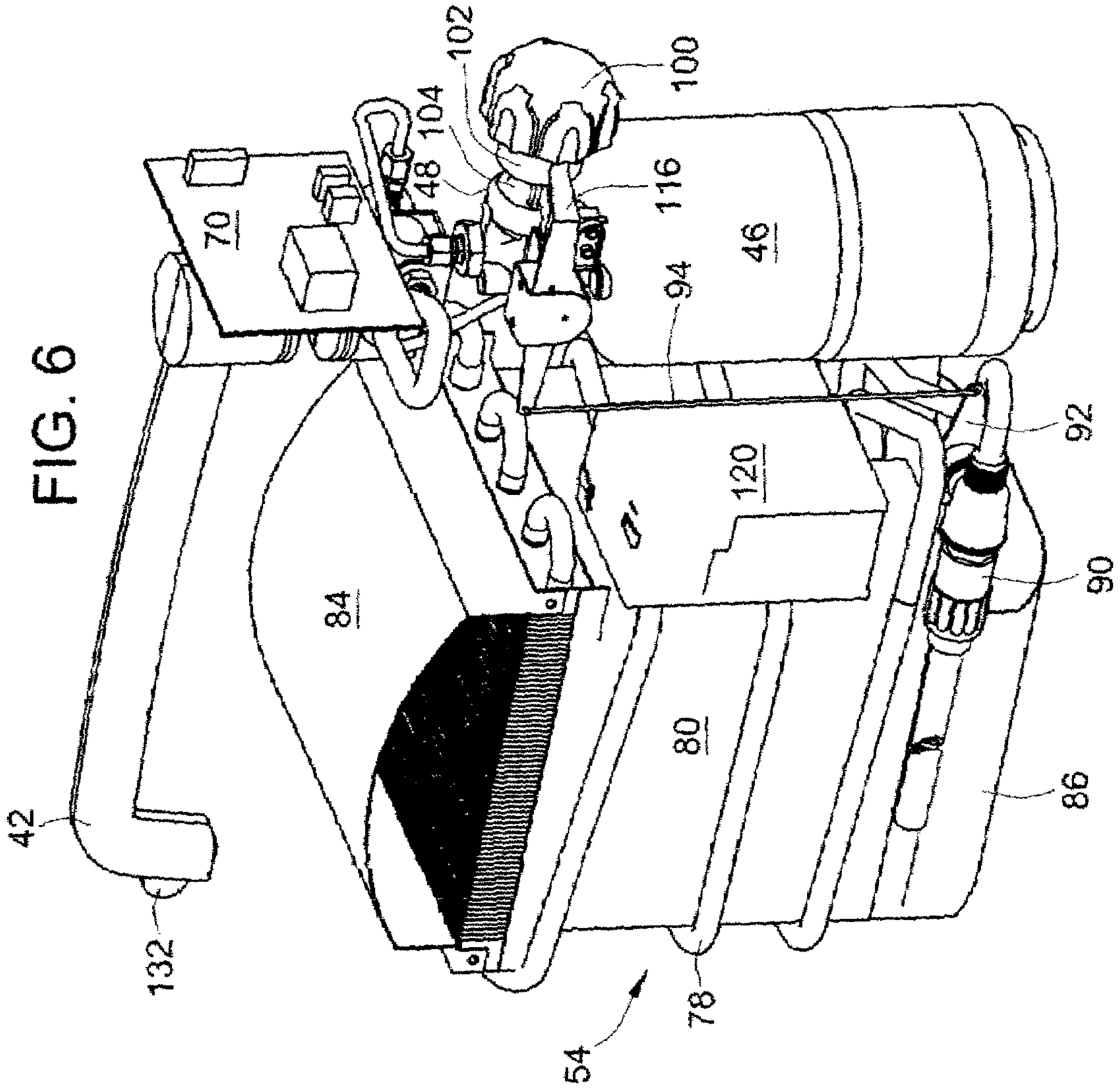


FIG. 7

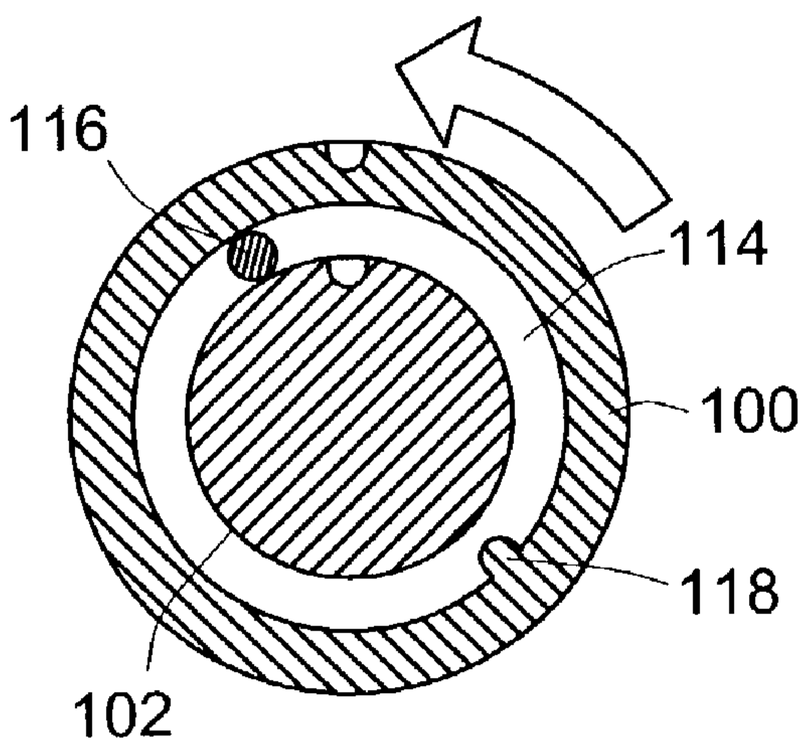


FIG. 8

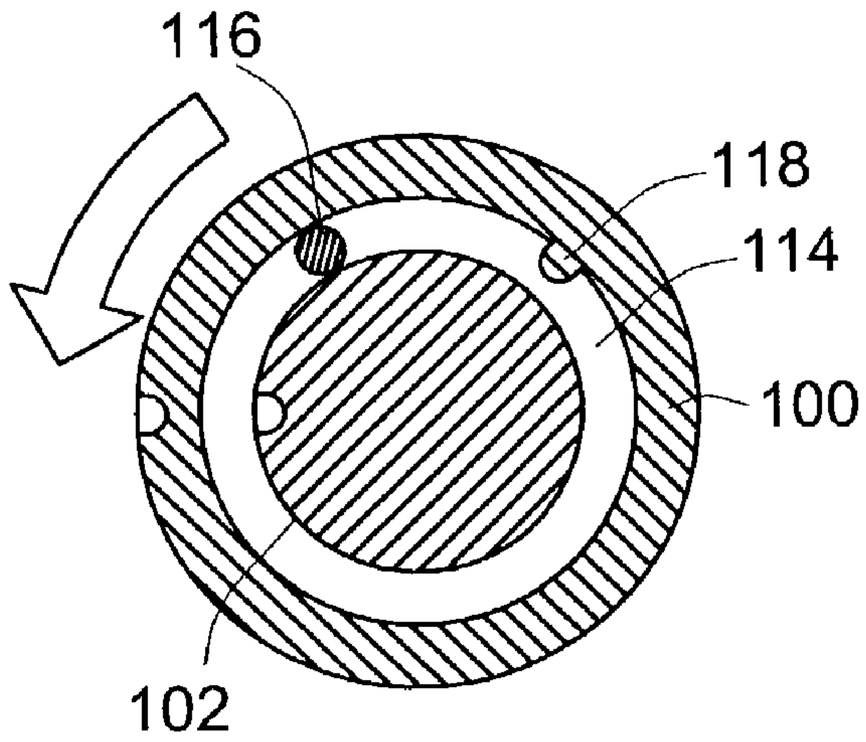


FIG. 9

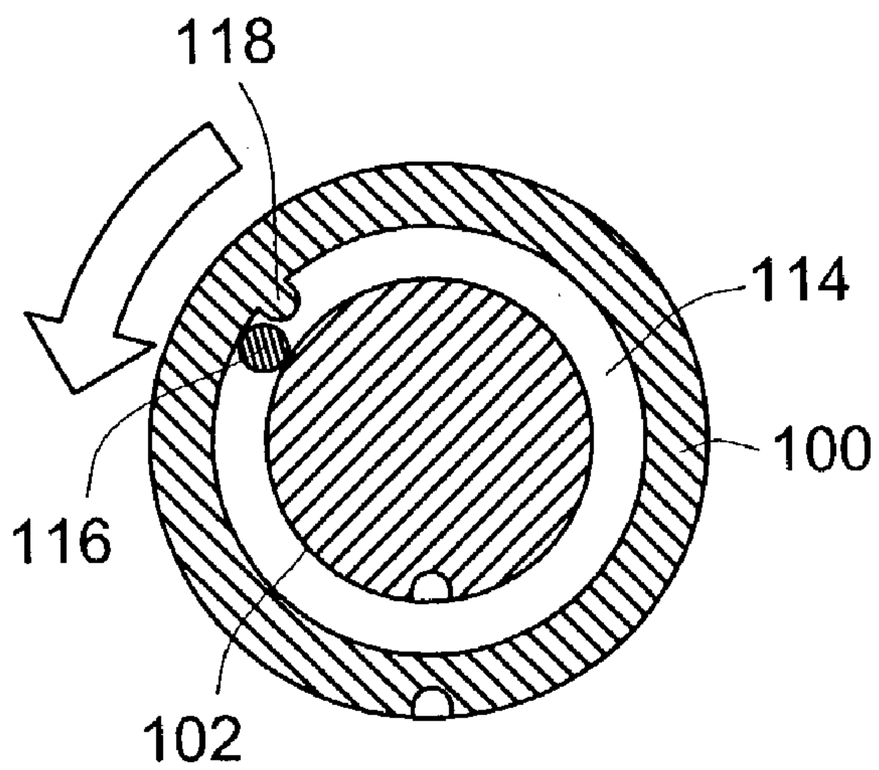
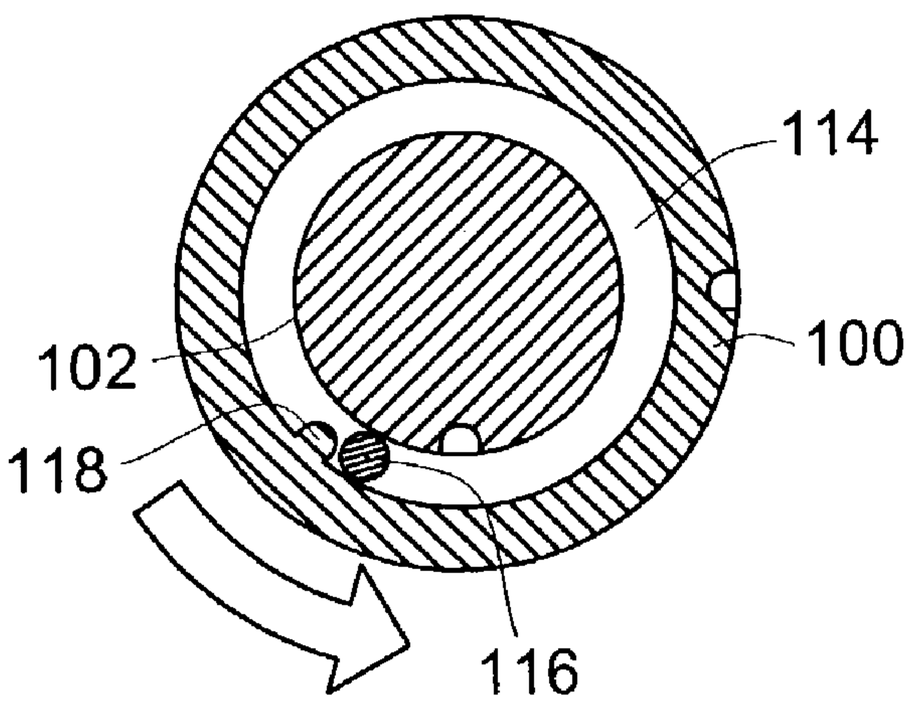


FIG. 10



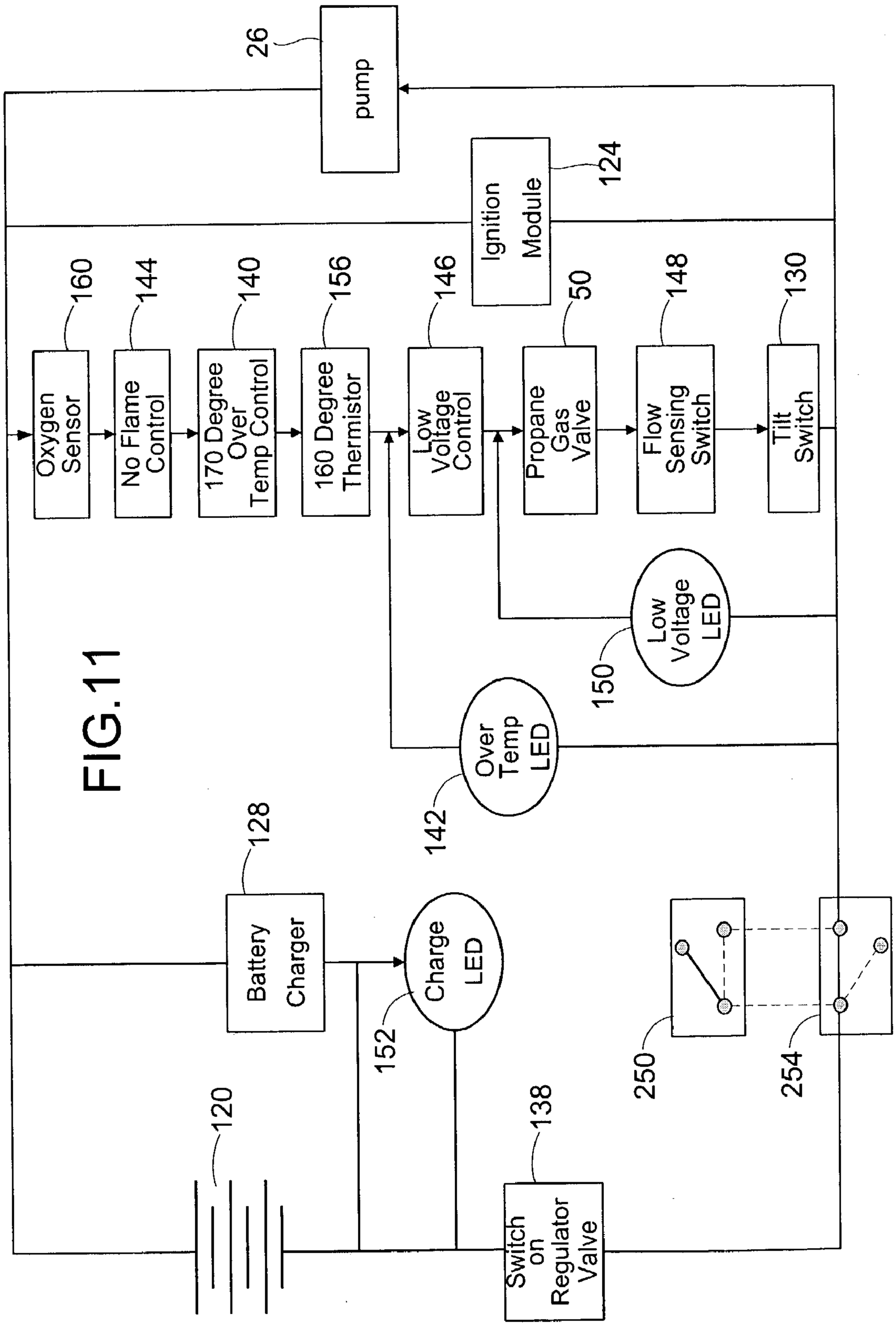

26
pump
124
Ignition Module
160
144
140
156
146
50
148
130
Oxygen Sensor
No Flame Control
170 Degree Over Temp Control
160 Degree Thermistor
Low Voltage Control
Propane Gas Valve
Flow Sensing Switch
Tilt Switch
Low Voltage LED
150
Over Temp LED
142
128
Battery Charger
Charge LED
152
120
138
Switch on Regulator Valve
250
254

FIG.11

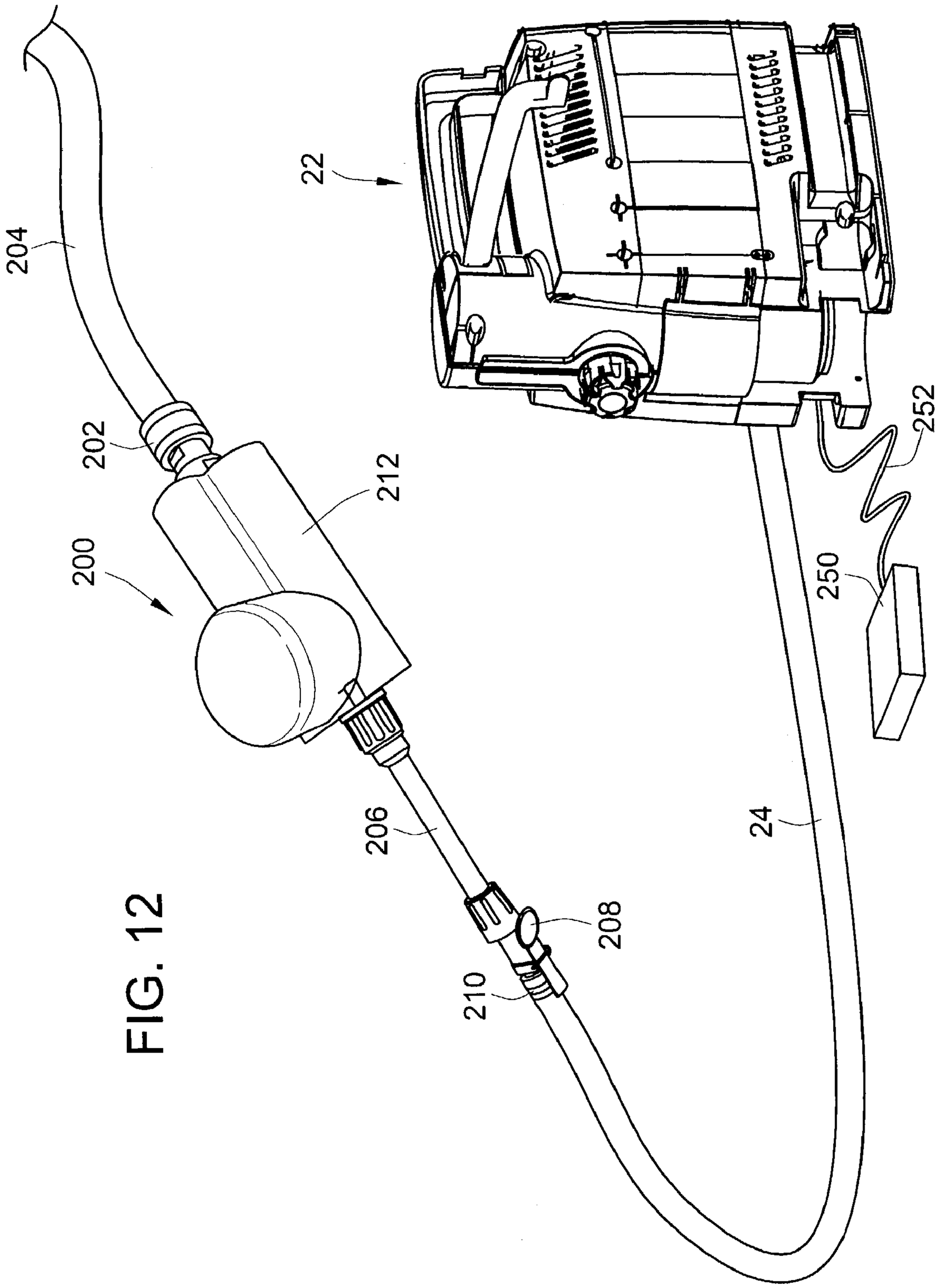


FIG. 12

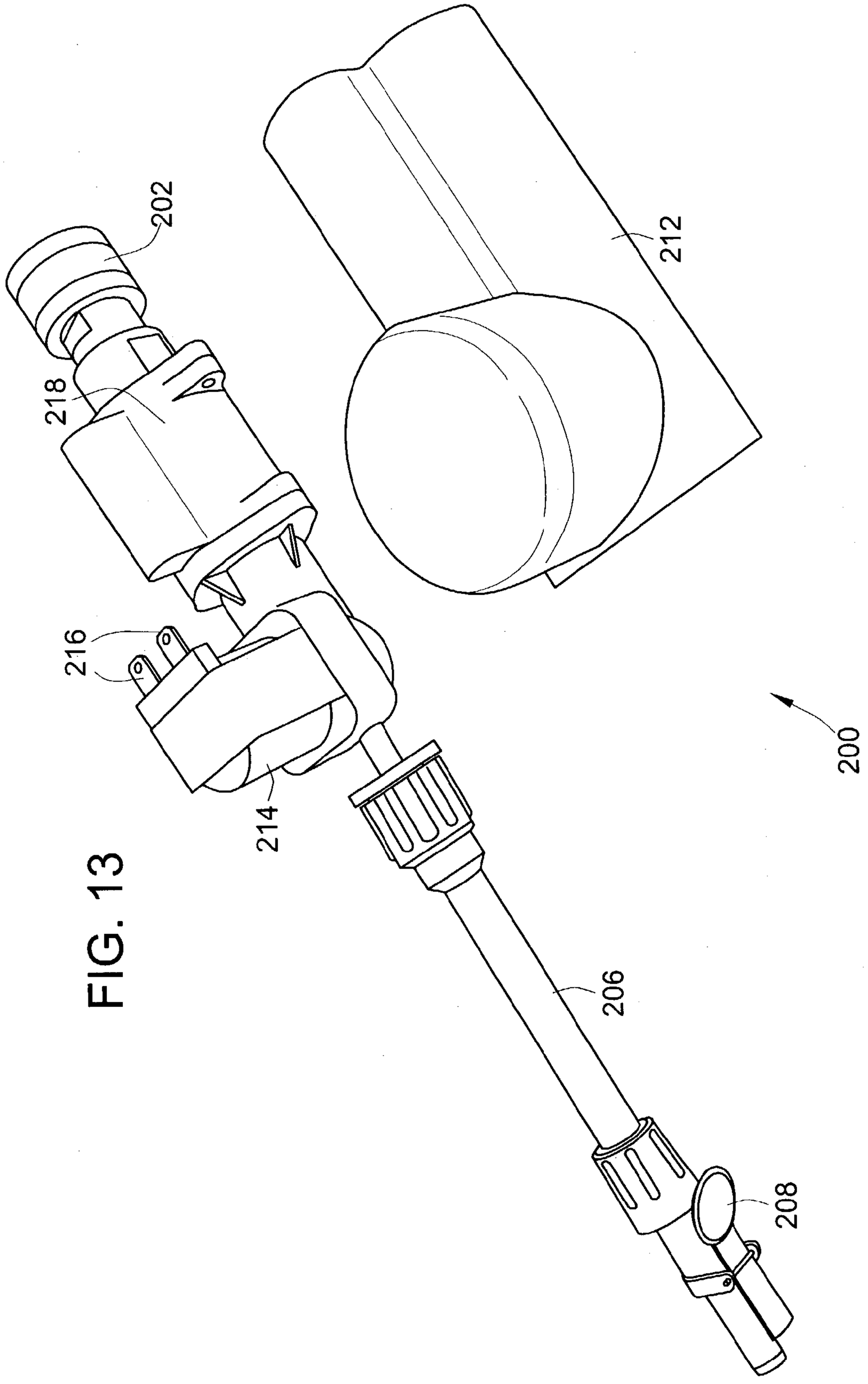


FIG. 13

FIG.14

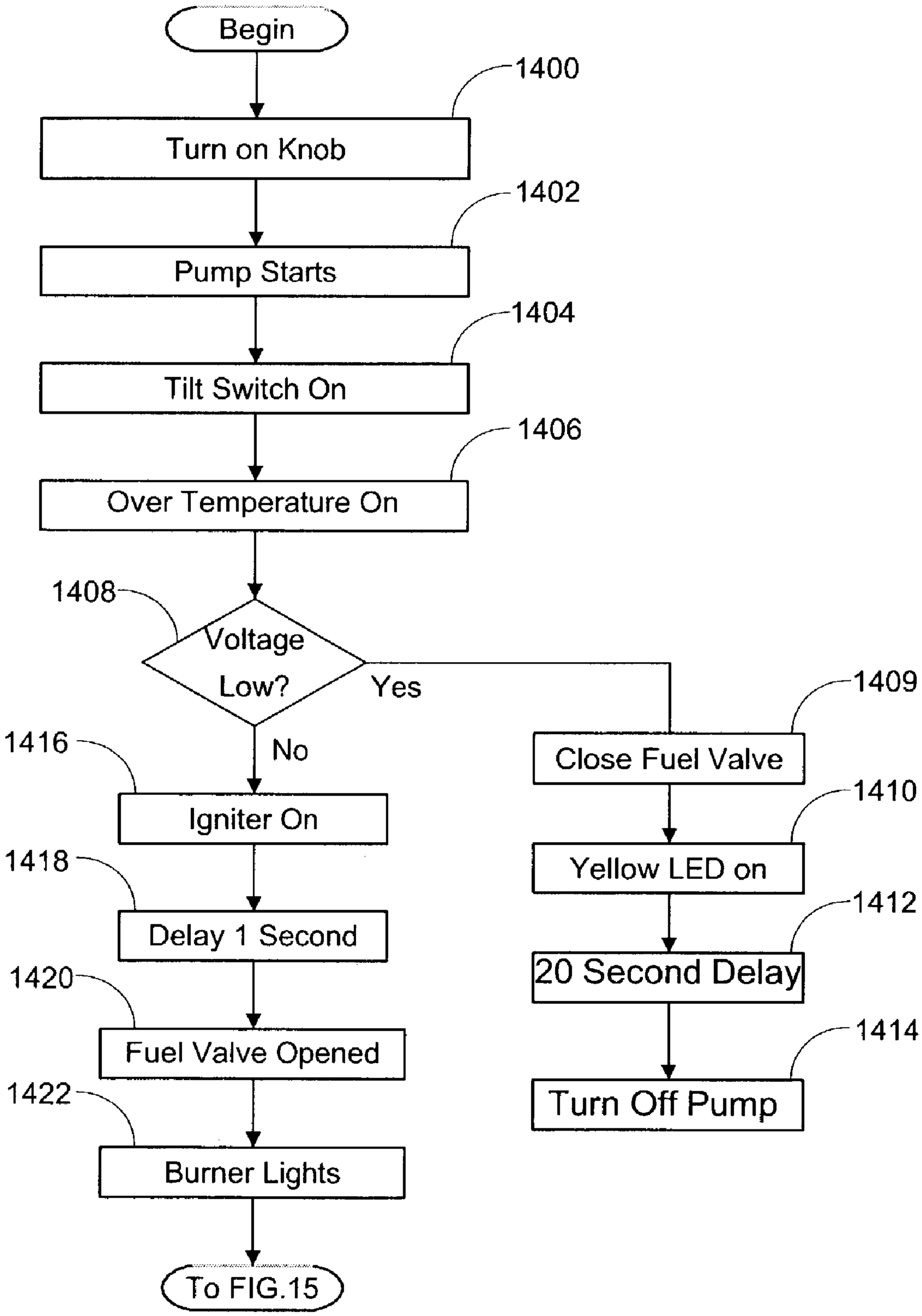
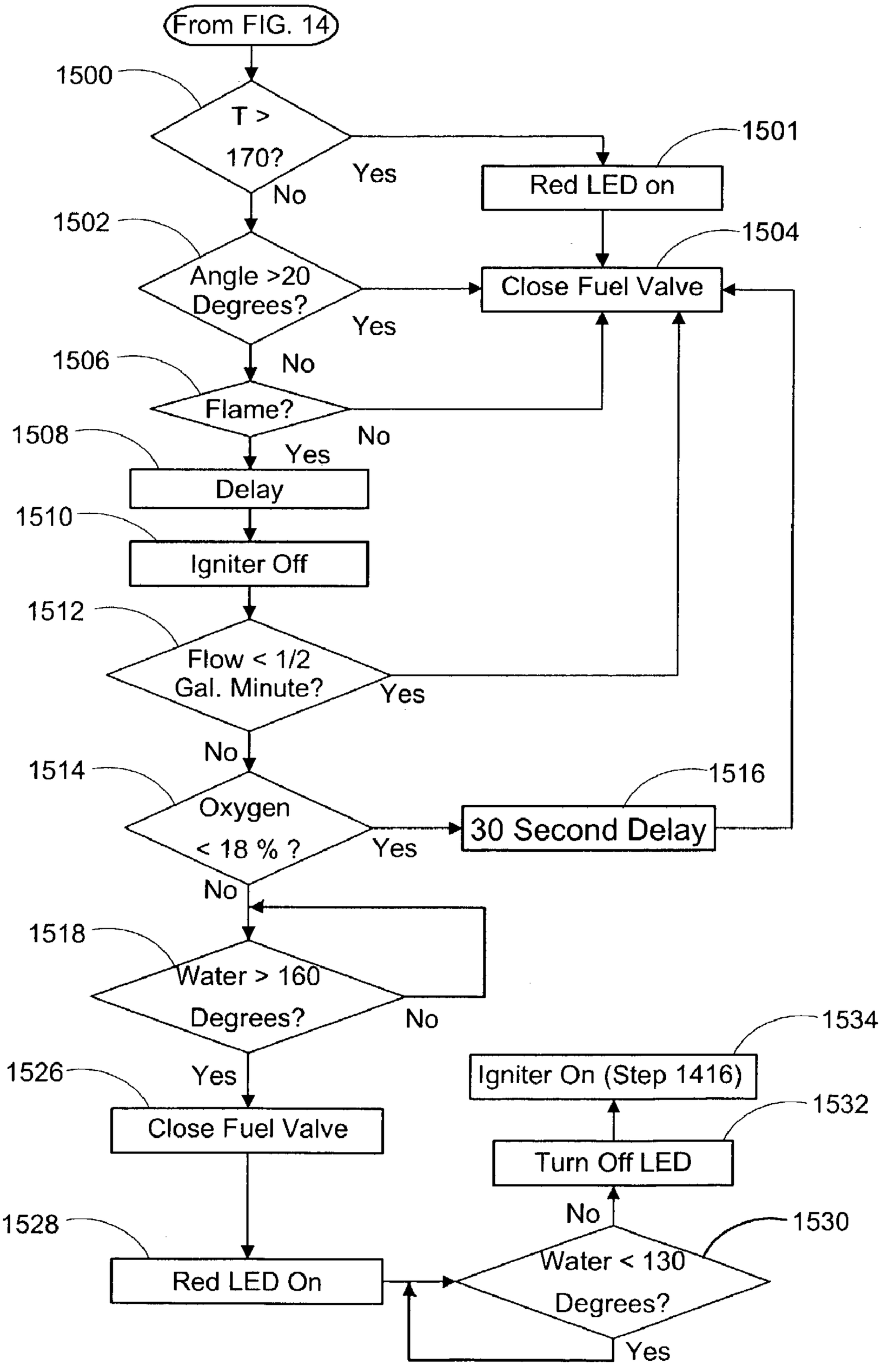

Begin
1400
Turn on Knob
1402
Pump Starts
1404
Tilt Switch On
1406
Over Temperature On
1408
Voltage Low?
Yes
No
1409
Close Fuel Valve
1410
Yellow LED on
1412
20 Second Delay
1414
Turn Off Pump
1416
Igniter On
1418
Delay 1 Second
1420
Fuel Valve Opened
1422
Burner Lights
To FIG.15

FIG.15


From FIG. 14
1500
T > 170?
Yes
No
1501
Red LED on
1502
Angle >20 Degrees?
Yes
No
1504
Close Fuel Valve
1506
Flame?
No
Yes
1508
Delay
1510
Igniter Off
1512
Flow < 1/2 Gal. Minute?
Yes
No
1514
Oxygen < 18 % ?
Yes
No
1516
30 Second Delay
1518
Water > 160 Degrees?
No
Yes
1526
Close Fuel Valve
1528
Red LED On
1530
Water < 130 Degrees?
Yes
No
1532
Turn Off LED
1534
Igniter On (Step 1416)

CONTROL SYSTEM FOR A PORTABLE INSTANT HOT WATER HEATER

TECHNICAL FIELD OF THE INVENTION

The present invention is directed to an instant hot water heater, and more specifically, a portable instant hot water heater.

BACKGROUND OF THE INVENTION

Camping and tailgating are popular recreational activities enjoyed by many. Some people camp so that they may enjoy the outdoors, and others use camping as an inexpensive alternative to staying in hotels. Tailgating is a great way to meet and eat before ball games, and has become quite the ritual for many season ticket holders.

Although many campers enjoy being in the outdoors, often campers like to enjoy the luxuries of home while camping. For example, many campers bring lounge chairs or hammocks, portable air mattresses or cots, and similar items to make a camping experience more comfortable. Similarly, people often like to enjoy home luxuries while tailgating.

One item that most campers and tailgaters have to learn to do without is the availability of hot water. Most homes are equipped with running hot water, supplied by a hot water heater that is connected with the home plumbing. The user simply turns on a faucet, and after a short delay, hot water is supplied. The hot water may be used for bathing, cleaning, cooking, or washing clothes.

In a camping or tailgating environment, if a user desires hot water, the user must obtain water, for example, from a faucet or other water source, and place the water in a container over a fire, such as a camp stove or an open fire. The water must then be heated to a desired temperature. This process typically takes several minutes, and water temperatures that are obtained using this process are relatively imprecise. The water that has been heated is hard to dispense because it is in a heated pot and the pots often are not designed for pouring. Also, if a user desires a lot of heated water, the process must be repeated until enough hot water is produced. Moreover, a user risks overheating the water to a point where it is dangerous to handle, especially for children.

In practice, because the process for preparing and obtaining heated water is so difficult when camping or tailgating, most users typically wash dishes, prepare food, and wash their face and hands with unheated water. Typically, the users will heat water only as necessary for food preparation and for making instant coffee and tea, for example.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key/critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

The present invention provides an instant water heater that utilizes a flame, for example, produced by a propane burner. The instant hot water heater is fully portable, and may be used, for example, in camping or tailgating environments. The instant hot water heater is configured to deliver varying degrees of hot water, for example ranging from 90° to 150°, instantaneously. The hot water heater is designed to operate regardless of the temperature of source water. Hot water from the instant hot water heater may be used for many applications, including but not limited to, washing dishes, food preparation, making coffee and tea, and washing face and hands.

Water is delivered to a base unit of the instant hot water heater by a pump that is attached to the base unit by a hose. The pump may draw water from a reservoir or other water source. Alternatively, water may be provided by a conventional hose or another water source.

The base unit includes a burner and a fuel source, such as a propane cylinder. A conventional battery operated igniter, such as is used for barbeque grills, may be provided for lighting a flame in the burner.

The pump delivers water to the base and into and through a flow control valve. From the flow control valve, the water flows into a pre-heater and then into a heat exchanger. The pre-heater includes a structure that wraps around a base of the burner and that is heated by the burner. This structure heats the water prior to the water entering the heat exchanger, increasing efficiency of the water heating process, and reducing the possibility of condensation being formed at the heat exchanger.

The heat exchanger is heated by the burner, and the water flows through coils that are embedded in the heat exchanger. Water exiting the heat exchanger is heated to a temperature that is ready for use.

Water exits the base unit through an outlet spout that resembles a kitchen faucet spout. The spout swings out from the base unit to dispense water. The spout may be stored and locked into position in a handle for the base unit, and may be swung out for use.

A flow control system controls the amount of water flowing through the base unit so that the water may be heated to a desired level for a user. By lowering the flow of water through the heat exchanger, the water has more time to absorb heat and to get hotter.

The base unit includes a single control knob that turns on the pump and the burner and operates the flow control valve. In a first portion of movement of the control knob (e.g., a first quarter-turns of the control knob), the pump and a control circuit for the base unit are turned on. In a second portion of movement of the control knob (e.g., a second quarter-turn of the control knob), the burner is turned on. Further movement in the second portion adjusts the output of the burner. The burner reaches full output at the end of the second portion. At a third portion of movement of the control knob (e.g., a third quarter-turn of the control knob), the burner remains at the highest output setting, but the flow control valve is adjusted to reduce the flow of water. The reduced flow of water allows the water to absorb more heat, raising the temperature of the water. In this manner, adjusting the single control knob provides a range of temperatures for the output water depending upon how much the control knob has been turned.

The base unit also includes an over temperature circuit that has a sensing element and a solenoid. The sensing element, which may be a thermistor, sends a signal to the solenoid as a result of the water exceeding a particular temperature. This condition may occur, for example, if water is no longer being supplied by the pump (i.e., the reservoir is empty.) As a result of the signal, the solenoid shuts off fuel to the burner, preventing boiling water from exiting the spout. Other safety devices may be employed, such as a device for sensing the tilt of the base unit and shutting off the burner as a result of too much tilt, a flow sensing switch that

shuts off the burner if there is no or low water flow, or a flame control that senses the presence of a flame in the burner, and absent such a flame, cuts fuel to the burner.

The instant hot water heater of the present invention is fully portable, and may be used in remote locations, such as for camping or for tailgating. Its function and operation are very easy to understand, and setting up the unit takes a minimal amount of time.

In accordance with another aspect of the present invention, the controls for the instant hot water heater may include an oxygen sensor, which determines whether or not oxygen in the air adjacent to the instant hot water heater is undesirably low. This feature prevents prolonged use of the instant hot water heater in an enclosed area, and precludes a user from being in an oxygen depleted environment created by the instant hot water heater.

The instant hot water heater may additionally include a foot switch for controlling operation of the instant hot water heater. The foot switch permits hands-free operation of the instant hot water heater, for example when a user desires to wash his or her hands, or needs both hands free for the filling of a pot or for the washing of dishes, for example.

The instant hot water heater of the present invention may additionally include a garden hose adapter that permits operation of the instant hot water heater without a water reservoir and the pump. The garden hose adapter may be attached to a conventional garden hose or a water faucet and includes a regulator or other flow control device to monitor the flow of water into the instant hot water heater, and may additionally include a solenoid valve or other device for stopping and starting the flow of water into the instant hot water heater.

Other advantages will become apparent from the following detailed description when taken in conjunction with the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric view showing an instant hot water heater in accordance with the present invention, with a spout for a base unit of the instant hot water heater extending outward, and a pump for the instant hot water heater connected to a water reservoir;

FIG. **2** is a front right isometric view of the instant hot water heater of FIG. **1**, showing the pump and the spout in storage positions;

FIG. **3** is a front right, isometric view of the instant hot water heater of FIG. **1**, with parts removed for detail;

FIG. **4** is a rear right, isometric view of the instant hot water heater of FIG. **1**, with parts removed for detail;

FIG. **5** is a right front, isometric view of the some internal components of the instant hot water heater of FIG. **1**;

FIG. **6** is a left front, isometric view of the instant hot water heater of FIG. **1**, with parts removed for detail;

FIGS. **7**–**10** are diagrammatic representation of a cross-section of a control knob for use with the instant hot water heater of FIG. **1**, the figures showing various stages of rotation of the control knob;

FIG. **11** is a schematic drawing of controls for the present invention;

FIG. **12** is a perspective view of the instant hot water heater of FIG. **1**, shown attached to a garden hose adapter;

FIG. **13** is a side perspective view of the garden hose adapter of FIG. **12**, with a cover removed to show detail; and

FIGS. **14** and **15** show exemplary steps for operation of the instant hot water heater of FIG. **1** in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

In the following description, various aspects of the present invention will be described. For purposes of explanation, specific configurations and details are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details. Furthermore, well-known features may be omitted or simplified in order not to obscure the present invention.

Referring now to the drawings, in which like reference numerals represent like parts throughout the several views, FIG. **1** shows an instant hot water heater **20** in accordance with the present invention. The instant hot water heater **20** includes a base unit **22** attached by a hose **24** to a pump **26**. In the embodiment shown, the pump **26** is attached to a reservoir **28**. A wire **30** extends between the pump **26** and the base unit **22** for providing power to the pump. For the embodiment shown, a coupling **32** is provided at a distal end of the pump **26** for attaching the pump **26** to the reservoir **28**.

In operation, as further described below, the pump **26** draws water from the reservoir **28** through the hose **24** and into the base unit **22**. The base unit **22** heats the water and provides the heated water at an outlet, for example, a spout **42**.

To store the instant hot water heater **20**, as shown in FIG. **2**, the hose **24** may be wrapped around the bottom portion of the base unit **22**, and the pump **26** may be snapped onto a snap ring **33**. The spout **42** is pressed into a handle **40** for the base unit **22**, as is further described below.

The pump **26** and the reservoir **28** may alternatively be replaced by a conventional water hose or another water source that provides a flow of water. If a water hose is used, a regulator or other flow control device may be needed to control the flow of water into the base unit.

An example of a garden hose adapter **200** is shown in FIGS. **12** and **13**. The garden hose adapter **200** includes a coupling **202** for attaching to a garden hose **204** or a conventional water faucet (not shown). A stem **206** extends from the opposite side of the garden hose adapter **202** and includes a clip **208** on its distal end. In use, the stem **206** may be inserted into the hose **24**, and the clip **208** may be extended over or behind a ring **210** or other protrusion on the hose **24**.

To attach the stem **206** to the hose **24**, a user presses a pad on the clip **208**, causing a distal end of the clip **208** to move against the bias of a spring (not shown) The stem **206** is then inserted, and the pad of the clip **208** is released, causing a protrusion on the clip **208** to extend behind or over the ring **210**.

The garden hose adapter **200** may be, therefore, attached in place of the pump **26**. Alternatively, the hose **24** may be removed, and the stem **206** may be attached directly to the base unit **22**.

The garden hose adapter **200** includes a cover **212**, which is removed to show detail in FIG. **13**. The garden hose adapter **200** includes a solenoid valve **214** which is configured and arranged to close the flow of water through the garden hose adapter **200**. The solenoid valve **214** includes power prongs **216** which may be connected to a power line (not shown) attached to the base unit **22**, or may utilize power provided via the wire **30**.

The garden hose adapter **200** also includes a regulator **218** which is configured in a manner known in the art to lower the pressure of water from the garden hose **204** to a usable pressure for the base unit **22**, in one embodiment to a water

pressure of 4 p.s.i. Alternatively, the regulator **218** may be replaced with a flow control device or another mechanism that may control the flow of water and the pressure of water into the base unit **22**.

The garden hose adapter **200** permits flexibility in the supply of water for the base unit **22**. Instead of the pump **26** and the water reservoir **28**, the garden hose adapter **200** may be used with the base unit **22** and a supply of water from a garden hose (e.g., the garden hose **204**). As such, the user does not have to continually refill the reservoir [water reservoir **28**?] for the production of a large amount of heated water. In addition, the garden hose adapter **200** allows the base unit **22** to be used in an outdoor home setting, such as to fill a small swimming pool. The base unit **22** includes left and right outer casings **34**, **36** that fit together in a clam shell fashion. The right outer casing **36** is shown removed in FIG. **3** so that details of the internal components of the base unit **22** may be seen.

Vents **38** (FIG. **2**) are provided outside of the base unit **22** for allowing heat to escape the unit. The handle **40** is integrated into the top portion of the base unit. The handle **40** extends horizontally along the top of the base unit **22**, and is attached at front and rear sections of the base unit. The spout **42** may be stored in a cavity that extends the length of the handle. The spout **42** is hollow and is rotatably mounted at one end to the base unit **22**. As can be seen in FIG. **1**, the spout may be rotated out so that it is accessible for dispensing heated water from the base unit **22**.

A control knob **44** is located on the front of the base unit **22**. The control knob **44** is configured so that it controls operation of the instant hot water heater **20**. As further described below, the control knob **44** is capable of turning on the pump **26** and other components of the instant hot water heater, and controlling the water output temperature of the base unit **22**.

Turning now to FIG. **3**, a propane tank **46**, such as a 16.4 oz. COLEMAN brand propane cylinder, is mounted inside the base unit **22**. The propane tank **46** is threaded into the bottom of a regulator **48**. The regulator **48** controls the flow of fuel from the propane tank **46** to a solenoid valve **50**. The regulator **48** includes female threads (not shown) for fitting onto the threaded top of the propane tank **46**. The regulator **48** is designed in a manner known in the art to control the amount of propane exiting the propane tank **46**. Fuel released by the regulator **48** flows through the solenoid valve **50** to a burner **52**, best shown in FIG. **5**. The burner **52** provides the flame for a heat exchanger assembly **54** (FIG. **3**).

The solenoid valve **50** is in a normally closed position, and is connected to a printed circuit board **70**. The printed circuit board **70** includes necessary controls to instruct the solenoid valve **50** to open, as further described below.

The burner **52** includes burner rings **72** (FIG. **5**). Extra burner rings **72** may be provided to provide a higher Btu output and to keep noise level to a minimum. For example, the burner rings **72** may be stacked 3 times higher than in a conventional camp stove so as to allow higher heat output.

A pre-heater assembly **74** is provided that is attached to the burner **52**. The pre-heater assembly **74** includes a copper plate **76** that is placed between the burner rings and a burner base **77**. Although described as copper, the copper plate **76** may be formed of another suitable conductive material.

The copper plate **76** is surrounded by conductive tubing **78**. The conductive tubing **78** may be, for example a ⅜" diameter copper tube.

The heat exchanger assembly **54** includes sides **80** (FIGS. **3** and **4**) that extend up and around the burner **52**. A heat exchanger **82** having heating fins is mounted at the top of the sides **80**. An upper heating shield **84** extends over the heat exchanger **82**. A lower heating shield **86** extends around a bottom of the heat exchanger assembly **54** and under the burner **52**.

The routing of the conductive tubing **78** is shown in FIG. **5**. The walls of the heat exchanger assembly **54** and the fins of the heat exchanger **82** have been removed to show detail. One end of the conductive tubing **78** extends from the pre-heater assembly **74** around the walls or sides **80** of the heat exchanger assembly **54** (shown wrapping around these walls in FIGS. **3** and **4**) and into the heat exchanger **82**. The conductive tubing **78** then makes a circuitous path through the heat exchanger **82**, as best shown in FIG. **5**. An end of the conductive tubing **78** extends into the bottom of the spout **42**.

The opposite end of the conductive tubing **78** that leads from the pre-heater assembly **74** extends to a flow control valve **90** (best shown in FIG. **6**). The flow control valve **90** is mounted to receive water from the pump **26** via the hose **24**. The flow control valve **90** is in a normally open position and includes a rocker arm lever **92**. A push rod **94** is connected to the rocker arm lever **92**. The flow control valve **90** also includes a return spring (not shown, but known in the art) for biasing the flow control valve **90** in the open position, and a low flow stop (also not shown) to prevent complete closure of the flow control valve **90**.

Details of the control knob **44** can be seen in FIG. **5**. The control knob **44** includes an outer knob **100** and an inner knob **102**. The outer knob **100** is mounted over and around the inner knob **102**. The inner knob **102** is mounted on a regulator shaft **104** for the regulator **48**. A torsion spring **106** fits between the inner knob **102** and the outer knob **100**. The torsion spring **106** fits into a pocket (not shown) in the rear of the outer knob **100**. Spring clip ends **110** of the torsion spring **106** fit into holes **112** on the inner knob **102** and outer knob **100** (the hole on the back of the outer knob is not shown, but is similar to the hole **112**), respectively.

A gap **114** (FIGS. **7**–**10**) is defined between the inner sidewall of the outer knob **100** and the outer sidewall of the inner knob **102**. An end of a flow valve lever **116** (shown in full in FIG. **6**, and a cross section of the end of which is shown in FIGS. **7**–**10**) extends into the gap **114** between the inner knob **102** and the outer knob **100**. The flow valve lever **116** is pivotably mounted to the base unit **22**, for example to a side of the regulator **48**. A forward end of the flow valve lever **116** extends outward toward the control knob **44** and bends at a first angle and then at a second angle so as to straighten back parallel to the rest of the flow valve lever **116**. This end of the flow valve lever **116** is seated in the gap **114** between the inner knob **102** and the outer knob **100**. The opposite end of the flow valve lever **116** is attached to the push rod **94** that in turn is attached to the rocker arm lever **92** of the flow control valve **90**.

A protrusion **118** (FIGS. **7**–**10**) is fixed on the inside surface of the outer knob is located in the gap between the outer knob **100** and the inner knob **102**. When the control knob **44** is in a normally closed position, the protrusion **118** is located approximately halfway around the outer knob **100** from the flow valve lever **116**. The function of the protrusion **118** is described further below.

A battery **120** is mounted in the base unit **22**. The battery **120** is connected to the printed circuit board **70**, the pump **26**, an ignition module **124** (FIG. **11**) for the burner **52**, and the solenoid valve **50**. If desired, the battery may include an integral or connected battery charger **128** (FIG. **11**). If so, an

AC or DC connector port **126** may be supplied on the outer shell of the base unit **22** for supplying power to the battery charger.

Operation of the instant hot water heater **20** may be understood with reference to the previous description and the circuit diagram at FIG. **11**. To set up the instant hot water heater **20**, a user disconnects the pump **26** from the snap ring **33** and unwinds the hose **24** from around the bottom of the base unit **22**. The coupling **32** on the pump **26** is attached to a water source, such as the reservoir **28**. Alternatively, the garden hose adapter **200** and a hose or water faucet (e.g., the garden hose **202**) may be attached to the base unit **22**. Preferably, the instant hot water heater **20** is placed on a level surface. By doing so, a flame in the burner **52** extends upward to the heat exchanger **82**, and there is no risk of overheating the wrong components in the instant hot water heater **20**. To this end, a tilt sensor or switch **130** (FIG. **11**) may be provided that is in a normally closed position, and that when the base unit **22** is not within a particular range of being level (e.g., +/−20 degrees), the switch is closed.

In any event, after the base unit **22** and the pump **26** are ready, the user rotates the spout **42** out of the handle **40**. If desired, a detente **132** (FIG. **3**) or other catch may be provided on the end of the spout **42** for fitting into a gap **133** on the handle **40**. The spout may otherwise be temporarily locked into the handle **40**. To permit the spout **42** to rotate without breaking the connection of the spout with the tubing **78**, the spout **42** may be mounted on an appropriate rotator piece **134** (FIG. **4**). Rotating connections that allow fluid to flow therethrough are well known, and a detailed description is not provided here so as not to obfuscate the invention. However, in one embodiment, the rotator piece **134** may be fixed to the spout **42**, and the tubing **78** below the spout may be flexible. The spout **42** rotates within a slot **136** on the outside of the base unit **22** until it extends outward as shown in FIG. **1**.

After the spout **42** has been rotated outward, the user actuates the control knob **44** by grasping the outer knob **100** and rotating it counterclockwise. A sequence of different stages of movement of the control knob **44** is shown in FIGS. **7**–**10**. In the first half turn of the outer knob **100** (movement from FIG. **7**, through FIG. **8**, to FIG. **9**), the inner knob **102** turns with the outer knob **100**. The flow valve lever **116** does not move during this rotation, but instead stays stationary in the same position within the gap **114**. In the first quarter of the movement (FIG. **7** to FIG. **8**), a switch **138** (FIG. **11**) in the regulator shaft **104** turns on the pump **26** and the printed circuit board **70**. Alternatively, if the garden hose adapter **200** is used, the switch **138** turns on the solenoid valve **214** and the printed circuit board **70**. Supplying power to the solenoid valve **214** opens the valve, allowing water to flow from the garden hose adapter **200** at the pressure set by the pressure regulator **218** (e.g., 4 p.s.i.).

During the first two portions of the movement of the control knob **44** (i.e., in the embodiment described, movement from FIG. **7** to FIG. **9**), water flows unimpeded through the flow control valve **90**. In the first quarter of a turn, the water flows through without being heated. A user will usually move quickly through this portion of movement of the control knob to the second portion. Continued movement of the outer knob **100** past the first quarter turn and into the second portion of movement (i.e., beyond FIG. **8** toward FIG. **9**) begins a supply of gas via the regulator **48** to the burner **52** and causes the ignition module **124** to fire.

Although the function, structure, and operation of the regulator **48** and the ignition module **124** are generally known, a general description is given here for the convenience of the reader. To start combustion in the burner **52**, the control knob **44** is rotated, in this case in a counterclockwise direction, causing the regulator shaft **104** to rotate. Rotation of the regulator shaft **104** causes two things to happen. First, the rotation of the regulator shaft **104** opens a valve (not shown), permitting the release of propane from the propane tank **46** and into the burner **52**. Second, rotation of the regulator shaft **104** causes the ignition module **124** to spark. The spark ignites the propane in the burner **52**, causing combustion.

Turning the control knob **44** further counterclockwise in the second portion of movement (i.e., from FIG. **8** to FIG. **9**) opens the valve even more, and increases the amount of propane supplied by the propane tank **46**, thus increasing the size of the flame in the burner **52**. Likewise, clockwise rotation of the control knob **44** while there is a flame in the burner **52** decreases the size of the flame. This flame adjustment may be used to increase or decrease the heat supplied to the heat exchanger assembly **54**.

In the second quarter of a turn, the heat exchanger assembly is heated to the extent of the flame size in the heat exchanger assembly **54**. Water flowing through the base unit **22** is heated by the heat exchanger assembly. The water flows from the flow control valve **90** through the conductive tubing **78** and around the copper plate **76**. As the water flows around the copper plate **76**, it is preheated before entering the heat exchanger **82**. This preheating of the water prior to it entering the heat exchanger **82** increases the efficiency of heating of water by the heat exchanger assembly **54** and reduces the likelihood of condensation being formed as a result of heating the water. The conductive tubing **78** extending around the sides **80** of the heat exchanger assembly **54** provides additional heating of the water before it enters the heat exchanger **82**, increasing the efficiency of the system.

In addition to the preheating effect provided by the copper plate **76**, the copper plate minimizes radiated heat on the bottom of the base unit **22**. The lower heat shield also enhances protection of the bottom of the base unit **22**.

A user may find that water exiting the spout **42** is sufficiently heated when the control knob **44** is in the second range of movement (i.e., between FIG. **8** and FIG. **9**). In this range of movement, the user may continue to rotate the knob in the counterclockwise direction, and doing so increases the burner flame, and the heat provided to the heat exchanger assembly **54** and the water flowing through the heat exchanger assembly. At the end of the second range of movement, the flame is at its maximum heat output, because the inner knob **102** cannot rotate any further because the regulator shaft **104** has hits the end of its range of rotation.

If the user wishes to increase the heat of the water even more, the user may continue to rotate the outer knob **100** past the half turn (i.e., counterclockwise beyond FIG. **9**). Although the inner knob **102** cannot rotate any further, the user may continue to rotate the outer knob **100** against the action of the torsion spring **106**. Simultaneous to the beginning of this movement, the protrusion **118** on the inside of the outer knob **100** engages the end of the flow valve lever **116** and begins to press it downward, driving the opposite end of the flow valve lever **116** upward, along with the push rod **94**. When the push rod **94** is driven upward, the rocker arm lever **92** of the flow control valve **90** is also driven upward. This movement of the rocker arm lever **92** causes the flow control valve **90** to begin to restrict the flow of water into the base unit **22**. The continued rotation of the outer knob **100** drives the end of the flow valve lever **116** down even further, from the position in FIG. **9** toward the position in FIG. **10**, further closing the flow control valve **90**. This

movement may continue, for example for a 45 degree turn of the outer knob **100**, until the flow control valve **90** reaches the low flow stop.

By decreasing the flow of water into the base unit **22**, the amount of water that is heated by the heat exchanger unit **54** is decreased. Thus, the heat that is transferred per unit water is increased. As such, the temperature of the water exiting the spout **42** is increased. Although the volume of the water over a defined increment of time exiting the spout **42** would be decreased, the temperature of that water would be higher.

In summary, the control knob **44** provides several operations for the base unit **22** and the pump **26**. A first portion of movement of the control knob **44** (in this embodiment, the first quarter turn) causes the pump **26** and the printed circuit **70** to be powered on. A second portion of the movement of the control knob **44** (in this embodiment, the second quarter turn) causes the burner **52** to be lit and adjust the length or output of the flame in the burner. A third portion of movement of the control knob **44** (e.g., a 45 degree turn after the first 90 degrees of motion) decreases the flow of water through the heat exchanger assembly **54**, thus increasing the temperature of the water without adding additional heat output. The three different functions for the control knob **44** may be performed by more than one control, or may be performed by a single control that performs one or more of these operations in a different manner. For example, the first portion may be provided by pushing a control knob inward, the second portion by rotating the knob, and a third portion by continued rotation of the knob or movement of the knob downward. However, the described control knob **44** is advantageous in that using the same movement (i.e., rotation of the knob) a user may turn on the instant hot water heater and may be provided a desired temperature of water, without knowing how the operation has occurred, or, if the user turns the control knob into the third portion, that the flow of water has been limited. Other single movement control mechanisms may be used, such as by having a control knob that portions of movement in one direction (e.g., downward) performs each of the three portions of operation for the instant hot water heater **20**.

In the embodiment shown, the second portion of operation by the control knob **44** provides a temperature delta of approximately 55° F. between inlet temperature of water and outlet temperature of water at the spout **42**. Thus, if water enters the base unit **22** at 65° F., the outlet temperature of the water at spout **42** would be approximately 110° F. If warmer water temperature is desired, the water flow must be reduced. As described above, this operation is accomplished by turning the outer knob **100** into the third portion of operation of the control knob **44**, which reduces the flow of water. The low flow stop prevents the flow of water from being so low that the unit would overheat.

The control system may include a device, such as a thermistor **156** (FIG. **8**), for cycling on and off the propane gas valve **50**. The thermistor **156** may, for example, turn off the propane gas valve **50** when a temperature hits 160 degrees Fahrenheit, and may turn the propane gas valve back on when the temperature hits 130. Operation of the thermistor **156** is further described below.

If desired, a safety over temperature control, which serves as a backup to the thermistor **156**, may be provided. The safety over temperature control may be, for example, a 170° F. over temperature control **140** (FIG. **8**) The over temperature control **140** may use a temperature sensing element, such as a thermistor to sense overheating of the heat exchanger assembly **54**. The over temperature control **140** may alternatively sense the temperature of water exiting the spout **42**. The over temperature control **140** is in a normally closed position, and exceeding an upper limit (e.g., 170° F.) causes the control to open. If desired, an over temperature LED **142**, which may be red, may be provided that is lit when the over temperature control opens to shut off the propane gas valve **50**.

Other controls may be provided to protect the base unit **22**. For example, a no flame control **144**, a low voltage control **146**, and a flow sensing switch **148** may all be provided for safety of the base unit **22**. As further described below, the flow sensing switch **148** may determine whether an adequate supply of water is flowing through the base unit **22**, the low voltage control **146** may determine whether there is adequate voltage to operate the base unit **22** and the pump **26**, and the no flame control **144** may sense whether a flame is operational in the heat exchanger unit **54**. For the diagram shown in FIG. **11**, each of these switches is in a normally closed position, and opening the switch causes the propane gas valve **50** to lose power and close, shutting off flow of gas to the burner **52**. If desired, one or more LEDs, such as a low voltage LED **150** may be provided for indicating conditions of the base unit **44**.

If desired, an oxygen sensor **160** (FIG. **11**) may be provided for sensing oxygen in the environment of the base unit **22**. The oxygen sensor **160** may be configured so that as long as oxygen is above a threshold, such as above 18% per volume, the oxygen sensor **160** is in a normally closed position. However, if oxygen falls below 18%, the oxygen sensor **160** may turn off the propane gas valve **50**, perhaps after a delay. In this manner, the oxygen sensor **160** may prevent prolonged usage of the base unit **22** in a closed area, such as inside a closed room or a closed space. Otherwise, the base unit **22** may cause a depletion of oxygen for a user in the vicinity of the base unit **22**.

The instant hot water heater **20** may also include an optional foot switch **250** (FIG. **12**). The foot switch **250** may connect via a cord **252** to the base unit **22**, and is configured so that a user may actuate the foot switch by pressure applied via a foot.

As can be seen in FIG. **11**, if the optional foot switch **250** is enabled, a normally closed switch **254** may be provided in the circuit for the instant hot water heater **20**. The normally closed switch **254** is closed when the foot switch **250** is not connected to the base unit **22**. However, when the foot switch **250** is connected to the base unit **22**, for example via a prong (not shown) inserted into a hole (also not shown) on the base unit **22**, then the connection of the foot switch **250** may open the normally closed switch **254**, for example by mechanically opening the normally closed switch via the prong connector, or by shorting an electrical connection that keeps the normally closed switch in the closed position.

When the foot switch **250** is connected to the base unit **22**, it resides in section of the circuit in which the normally closed **254** normally resides. That is, the circuit routes through the foot switch **250** instead of the normally closed switch **254**. The foot switch **250** includes a normally open switch therein, and actuation by a foot of the user, such as by stepping on the foot switch **250**, closes the circuit.

To use the foot switch **250**, a user attaches the foot switch **250** to the base unit **22** so as to open the normally closed switch **254**. The user may then set the control knob **44** as desired, but because the circuit is opened through the foot switch **250**, the unit does not operate. However, if the user steps on the foot switch **250**, then operation of the pump **26** and the base unit **22** begins. In this manner, a user may utilize the foot switch **250** so that hands-free operation of the instant hot water heater **20** is enabled.

The printed circuit board **70** may include the necessary control components to operate the functions of the instant hot water heater **20**. The printed circuit board **70** may be alternatively be standard control (i.e., a device or mechanism used to regulate or guide the operation of a machine, apparatus, or system), a microcomputer, or any other device that can execute computer-executable instructions, such as program modules. Generally, program modules include routines, programs, objects, components, data structures and the like that perform particular tasks or implement particular abstract data types. A programmer of ordinary skill in the art can program or configure the printed circuit board **70** to perform the functions described herein.

FIG. **14**–**15** show exemplary operation of the instant hot water heater **20** in accordance with one embodiment of the present invention. For many of the steps shown in FIGS. **14** and **15**, the operation or step may be real time, in that if a particular decision occurs at any point in operation, the resultant step may occur. For example, if, during any point in operation of the instant hot water heater **20**, the over temperature control **140** or another temperature sensor senses that the temperature of the water is over 170 degrees Fahrenheit, the propane gas valve **50** may be closed. However, in order to simplify description of the operation of the instant hot water heater **20**, the steps are set forth as shown in FIGS. **14** and **15**.

Beginning at step **1400**, a user turns on the control knob **44**. At step **1402**, the pump **26** starts. At step **1404**, the tilt switch **130** is turned on. At step **1406**, the over temperature control **140** is turned on.

At step **1408**, the low voltage control **146** determines whether the voltage for the instant hot water heater **20** is low. If so, step **1408** branches to step **1409**, where the fuel valves closes, and then to step **1410**, where the yellow low voltage LED **150** is lit. After a **20** second delay in step **1412**, the pump **26** is turned off at step **1414**. If the low voltage control **146** does not sense that the voltage is low, then step **1408** branches to step **1416**, where the ignition module **124** is turned on. At step **1418** there is a one second delay and then the propane gas valve **50** is opened in step **1420**. In preferred operation, the burner **52** lights in **1422**. The process then proceeds to FIG. **15**.

At step **1500**, the over temperature control **140** determines whether the temperature of water exiting the instant hot water heater **20** exceeds a threshold, for example, 170 degrees Fahrenheit. If so, step **1500** branches to step **1504**, where the propane gas valve **50** is closed. Alternatively, in this step and other instances where closing of the propane gas valve **50** is referenced, the microcontroller may handle differently, such as by lowering output of the burner **52**, increasing flow rate from the pump **26**, or otherwise adjusting the instant hot water heater **20** to safely handle the sensed situation.

In any event, if the temperature threshold is not exceeded, then step **1500** branches to step **1502**, where the tilt switch **130** determines whether the angle is greater than 20 degrees. If the angle is greater than 20 degrees, then step **1502** branches to step **1504**, where the propane gas valve **50** is closed. If the angle is not greater than 20 degrees, then step **1502** branches to step **1506**, where a determination is made by the no flame control **144** whether a flame is present in the burner **52**. If not, then step **1506** branches to step **1504**, where the propane gas valve **50** is closed. If a flame is present in the burner **52**, then step **1506** branches to step **1508** where a delay, such as 3 seconds, occurs, and then the ignition module **124** is turned off in step **1510**.

The process then proceeds to step **1512**, where a determination is made whether the flow rate of water through the instant hot water heater **20** is less than a threshold, for example, one half gallon per minute. This determination may be made, for example, by the flow sensing switch **148**. If the flow rate is less than one half gallon per minute, then step **1512** branches to step **1504**, where the propane gas valve **50** is closed. If the flow rate is greater than one half gallon per minute, then step **1512** branches to step **1514**, where the oxygen sensor **160** determines whether the oxygen in the adjacent air is greater than 18% per volume. If the oxygen is not greater than 18% per volume, then after a 30 second delay in step **1516**, the propane gas valve **50** is closed at step **1504**.

If the oxygen is greater than 18%, then step **1514** branches to step **1518**, where the beginning of operation of the thermistor **156** is shown, continuing through step **1534**. At step **1518**, a determination is made if the water temperature in the base unit **22** is greater than 160 degrees Fahrenheit. If the water is not greater than 160 degrees, then the process branches back until the burner **52** causes the water to exceed 160 degrees. The water may never exceed 160 degrees, and the process may continue the loop at step **1518**.

If the water does exceed 160 degrees, then step **1518** branches to step **1526**, where the propane gas valve **50** is closed. A red LED (e.g., the LED **142**) may be lit to indicate that the propane gas valve **50** has been closed and that the burner **52** is not operating at step **1528**. The process then proceeds to step **1530**, where a determination is made whether the water exceeds 130 degrees. If it does exceed 130 degrees, then the process loops back onto itself until the water drops below 130 degrees. When the water drops below 130 degrees, the red LED **142** is turned off in step **1532**, and then the ignition module **124** is turned back on in step **1534**, and the process returns to step **1460**.

In the described embodiment, it takes about three seconds for heated water to come out of the spout **42** after a user begins operation of the instant hot water heater **20**. There is control of the water temperature that exits the spout **42** from inlet temperature to approximately 150° F. To provide this heat of water, the regulator is adjustable from zero fuel to 30,000 Btus. In addition, the flow control valve **90** is adjustable from one gallon per minute to ½ gallon per minute.

For the described embodiment, a single 16 oz. propane cylinder can produce around 40 gallons of heated water, assuming the flow control valve **90** is not limiting the flow of water. If desired, a user may connect the base unit **22** to a 20 lb. propane cylinder with a hose so that extended use may be provided.

The instant hot water heater **20** provides varying degrees of hot water instantaneously. The instant hot water heater **20** can be transported and may be used in all locations, such as for camping or tailgating, and may be used for many applications including washing dishes, food preparation, making coffee and tea, and washing face and hands.

Other variations are within the spirit of the present invention. Thus, while the invention is susceptible to various modifications and alternative constructions, a certain illustrated embodiment thereof is shown in the drawings and has been described above in detail. It should be understood, however, that there is no intention to limit the invention to the specific form or forms disclosed, but on the contrary, the intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention, as defined in the appended claims.

What is claimed is:

1. An instant hot water heater, comprising:

a base unit;

a heat exchanger in the base unit for heating water;

a combustion device for heating the heat exchanger; and

a control system for effecting safe operation of the base unit, wherein the control system comprises an oxygen sensor that provides a signal if an oxygen level for the instant hot water heater falls below approximately 18% Oxygen by volume.

2. The instant hot water heater of claim **1**, wherein the signal is used to stop operation of the combustion device.

3. An instant hot water heater, comprising:

a base unit;

a heat exchanger in the base unit for heating water;

a combustion device for heating the heat exchanger;

a control system for effecting safe operation of the base unit, wherein the control system comprises:

an oxygen sensor that provides a signal if an oxygen level for the instant hot water heater falls below a defined threshold; and

a tilt sensor that detects an angle at which the base unit is resting, and which provides a signal if the base unit the angle is outside a threshold.

4. The instant hot water heater of claim **3**, wherein the signal is used to stop operation of the combustion device.

5. An instant hot water heater, comprising:

a portable base unit for heating water, the base unit comprising a handle for carrying the base unit;

a foot pedal switch for turning on and off operation of the base unit; and

a control for operating the base unit, the control being capable of operating the base unit independent of the foot pedal when the foot pedal is not attached to the base unit.

6. The instant hot water heater of claim **5**, wherein actuation of the foot switch is required to operate the base unit when the foot switch is attached to the base unit.

7. An instant hot water heater, comprising:

a base unit for heating water;

a foot pedal for controlling operation of the base unit;

a control for operating the base unit, wherein the control is capable of operating the base unit independent of the foot pedal when the foot pedal is not attached to the base unit and wherein actuation of the foot pedal is required to operate the base unit when the foot pedal is attached to the base unit.

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